

**REMARKS**

Claims 1-30 and 54 are pending in the application. Independent claims 1, 20, and 54 have been revised to recite a solid oxide fuel cell that is prepared by a process whereby at least the solid electrolyte and anode are prepared by co-firing or sintering at least two layers to form a porous anode layer and a dense solid electrolyte layer, whereby the process results in fusion of like particles of the ceramic-metal composite anode and the solid electrolyte. This language now added to claims 1 and 54 is taken from 5,670,270 to Wallin, which is incorporated by reference in its entirety on page 11, line 3, and page 12, lines 5 and 6 of the present specification. No new matter is presented by the amendments. Accordingly, applicants respectfully request entry thereof and reconsideration of claims 1-30 and 54 in light of the following remarks.

Prior to discussing the merits of the Action, applicants and the undersigned wish to thank Examiner Yuan for the courtesies extended during the telephonic interview held on August 25, 2005. The undersigned and the Examiner discussed the amendments made herein, and no agreement was reached. The Examiner stated that the language added to the claims may not distinguish the claims over the Cable reference (discussed in detail below with respect to the prior art rejection) because, in his opinion, fusion might occur between the electrolyte and anode in Cable at Cable's operating temperature of 1,000°C. Applicants' representative respectfully disagreed with the Examiner, and stated that evidence refuting the Examiner's allegation would be submitted in response to the Action. Such evidence is provided below.

Page 2 of the Action objects to claim 20 as containing a typographical error ("togetherto" was mis-typed as a single word). Claim 20 has been revised to correct this obvious error.

Applicants appreciate with thanks the withdrawal of previous prior art rejections noted on page 2 of the Action.

Pages 2-5 of the Action reject pending claims 1-6, 9-27, 30, and 54 under 35 U.S.C. §103(a) as being unpatentable over Gorte, *et al.*, U.S. Patent No. 6,589,680 ("Gorte"), in view of Anumakonda, *et al.*, U.S. Patent No. 6,221,280 ("Anumakonda"). Applicants respectfully traverse this rejection.

Gorte is available as prior art to the present application only under the provisions of 35 U.S.C. §102(e) because it was issued after the filing date of the present application. Consequently, Gorte cannot preclude patentability under 35 U.S.C. § 103 on the basis that Gorte and the instant application were, at the time the invention was made, owned by, or subject to an obligation of assignment to, The Trustees of the University of Pennsylvania. Applicants submit the following statement in accordance with MPEP § 706.02(l)(1):

**STATEMENT CONCERNING COMMON OWNERSHIP**

Applicants respectfully submit that, on the date the present application was filed, the present invention and Gorte were commonly owned by or subject to assignment to The Trustees of the University of Pennsylvania, and therefore Gorte cannot be prior art under 35 U.S.C. § 103(a).

Gorte therefore cannot be used to reject the present claims under 35 U.S.C. §103. Accordingly, applicants respectfully request that the Examiner reconsider and withdraw this rejection.

On pages 6-8 of the Action, claims 1-6, 9-19, and 54 are rejected under 35 U.S.C. §103(a) as being unpatentable over Cable, *et al.*, U.S. Patent No. 5,589,285 ("Cable") in view of Anumakonda. The Action alleges that Cable teach a solid oxide fuel cell comprising an anode of sulfur tolerant material. The Action apparently recognizes the differences between the present invention and Cable insofar as Cable requires a non-bonded cell, but notes that the presently rejected claims are product-by-process claims. The Action asserts that since Cable's actual anode material is similar to that of the applicants, applicants' process is not given patentable weight in this claim. The Action relies on Anumakonda as disclosing the use of sulfur-containing heavy hydrocarbon fuels for a solid oxide fuel cell. The Action concludes that the combination of the Cable and Anumakonda renders obvious claims 1-6, 9-19, and 54. Applicants respectfully traverse this rejection.

Cable appears to disclose sulfur tolerant fuel cells, but these cells are made by a special process that avoids bonds or fusion between the electrolyte and electrodes by placement of interfacial layers, slip zones, and the like, between the respective components. The present claims, in contrast, recite forming the electrolyte and anode by co-firing the two layers together to form a composite in which at least some of the like particles of the anode and electrolyte are "fused" together. This type of cell is described in Cable as a "bonded"

fuel cell. Cable teaches that bonded fuel cells could not process sulfur, and consequently, Cable requires non-bonded fuel cells with various separator and microslip layers positioned between the electrolyte and electrodes. The present inventors therefore achieved what Cable said was not possible — a bonded sulfur-tolerant fuel cell.

With respect to bonded fuel cells, Cable states the following:

The cofired or bonded solid oxide electrolyte fuel cells have practically no tolerance to sulfur bearing fuels. The performance of the cofired or bonded solid oxide electrolyte fuel cells degrades considerably when used in a process to utilize sulfur bearing fuels, even at concentrations as low as 1 part per million (ppm).

\* \* \*

We have found that nonbonded solid oxide electrolyte fuel cells can utilize sulfur bearing fuels with surprisingly stable performance over extended periods of time.

\* \* \*

The present invention therefore provides a process for utilizing a sulfur bearing fuel in an electrochemical apparatus including introducing a fuel containing at least 2 ppm sulfur species, at reaction temperature, into a non-bonded solid oxide electrolyte fuel cell, and reacting said fuel.

Cable, at col. 2, line 4 to col. 3, line 9. Cable creates a nonbonded solid oxide electrolyte fuel cell by placing an interfacial layer, or other separator(s) between the electrolyte and the electrodes (e.g., anodes and cathodes) (*see*, col. 3, line 10 to col. 4, line 58, and the examples).

Cable states further:

We have further found that solid electrolyte fuel cells having nonbonded electrodes respond differently to sulfur than do bonded or cofired fuel cells. Bonded fuel cells, such as those described in the Westinghouse publications, exhibit a continued decrease in performance so long as sulfur bearing fuel is utilized, with a resumption of former activity when sulfur is removed, but a repeated degradation with the reintroduction of the sulfur bearing fuel. This is symptomatic of a surface adsorption/active site poisoning mechanism being involved.

Cable, at col. 5, lines 26-35. Cable therefore teaches directly away from a solid oxide fuel cell that is formed by co-firing the electrolyte and electrode(s) together to form a bonded (or fused) cell arrangement. Cable avoids any bonding by placing various separators, microslip zones, and interfacial layers between the electrolyte and each electrode. Cable therefore fails to teach the presently claimed fuel cell. Anumakonda fails to cure the

deficiencies of Cable. Accordingly, the combination of the Cable and Anumakonda fails to render obvious the present claims.

The Examiner stated during the interview that the language proposed by the applicant may not distinguish over Cable because, in his view, Cable operates the fuel cell at 1,000°C, and at that temperature, the electrolyte and electrode of Cable might fuse to one another. Applicants respectfully disagree with the Examiner's allegation, and even if true, the allegation falls far short of satisfying the Patent Office's burden in establishing obviousness.

The Examiner appears to allege that Cable's cell "inherently" fuses together by causing sintering between the electrolyte and electrode at the fuel cell operating temperature. Cable specifically teaches away from fusing the materials together, so the Examiner's allegation flies in the face of Cable's express teaching. In addition, the Examiner has come forward with no evidence that sintering will occur, other than an allegation that sintering "might" occur, which has been repeatedly held at the Federal Circuit to be insufficient to support a theory of inherency. Moreover, Cable positions interfacial layers and microslip zones between the electrolyte and anode to prevent contact (and presumably any fusion) between the two layers. Accordingly, even if some sintering were to occur at Cable's operating temperature as alleged by the Examiner, applicants believe that these additional layers and zones would preclude fusion of like materials present in the electrolyte and anode layers.

Applicants attach hereto (and explain in further detail below) a number of publications describing acceptable sintering temperatures for YSZ-NiO anodes (the very anodes utilized in Cable's examples), which are much higher than Cable's fuel cell operating temperature of 1,000°C. One document states that temperatures on the order of 1,300°C are too low to provide a good bond between the electrolyte and electrode when a YSZ-NiO anode is used.

Applicants respectfully submit that it is improper for the PTO to take the position that fusion or sintering inherently occurs in Cable's system. Cable specifically avoids fusion, and specifically states, as excerpted above, that a fused, or bonded, solid oxide electrolyte fuel cell is incapable of processing sulfur-containing fuels. Thus, if fusion were to occur, then that fusion would completely destroy the entire purpose and function of Cable's cell, which

is to process sulfur-containing fuels. The PTO therefore cannot take the position that use of Cable's fuel cell will result in a fuel cell that Cable itself says is not useful.

Cable operates its fuel cell at a temperature of as high as 1,000°C, which is on the high end of typical operating conditions for fuel cells. Sintering YSZ cermets, like the YSZ-NiO cermet used as Cable's anode material, typically takes place at temperatures from about 1,250 to 1,400°C.<sup>1</sup> Applicants attach hereto the following evidence:

Isenberg, U.S. Patent No. 4,597,170 - discloses sintering fuel electrodes (anodes) comprised of YSZ-NiO at temperatures of 1,300 - 1,350°C is too low to provide a good electrode bond to the electrolyte (col. 1, line 62 to col. 2, line 4);

Mamak, *et al.*, "Practical Solid Oxide Fuel Cells. . .," *Chem. Commun.*, 2002, 2300-2301 - discloses sintering YSZ-NiO cermets at 1,100°C was not sufficient, but sintering at 1,400°C was acceptable;

Printout from website. [www.fuelcellmaterials.com](http://www.fuelcellmaterials.com), which offers YSZ-NiO cermet materials for use in making SOFC anodes - sintering temperatures are from 1,200 - 1,400°C;

Lu, *et al.*, "Development of Solid Oxide Fuel Cells . . .," *Solid State Ionics*, 152-153 (2002), pp. 393-397 - discloses cracking and poor sintering results when sintered at 1,300°C, and thus recommends sintering at 1,400°C; and

Huang, *et al.*, "Fabrication of Sr-Doped LaFeO<sub>3</sub> YSZ Composite Cathodes," *J. of Electrochem. Soc.*, 151 (4) A646-A651 (2004) - discloses ineffective YSZ sintering at 1,100°C, the problems associated with adverse phase formation and solid state reactions in sintering cathodes at higher temperatures, and the need to have a sintering temperature for the cathode high enough to allow sintering of the YSZ phase to the electrolyte, but low enough to prevent solid state reactions - the document therefore sinters YSZ at above 1,500°C, and then impregnates it with cathode components and calcines at a much lower temperature to avoid the solid state reactions, but yet still create a good electrolyte/electrode bond by virtue of the high temperature sinter.

There are legions of other references disclosing conventional YSZ sintering temperatures within the range of 1,200 to over 1,400°C. It also is very well known that fuel

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<sup>1</sup> Applicants own specification discloses sintering at about 1,500°C, and Wallin, U.S. Patent No. 5,670,270, which is incorporated by reference into the present specification, discloses sintering at 1,250°C. The Examiner will appreciate that the sintering step in Wallin is carried out on a tri-laminate preform comprising the anode/electrolyte/cathode, whereby it is known to sinter at lower temperatures to prevent adverse phase formation and solid state reactions at the cathode. Even so, this temperature is 250°C above Cable's operating temperature.

cells must be comprised of materials that are stable at the fuel cell operating temperature (*see*, the present specification, at page 1, lines 11-16). It would appear to be illogical to fabricate a fuel cell out of a material that would disintegrate, fuse, anneal, or sinter at the operating temperature of a fuel cell, and consequently, would not be stable at the fuel cell operating temperature. This would be akin to fabricating an automobile engine from materials that melt at conventional operating temperatures. The evidence presented herein therefore reveals that operating Cable's fuel cell at a temperature of 1,000°C would not result in fusion of the electrolyte and electrode like materials, as recited in the present claims, since such fusion would not take place to any appreciable extent until the temperature reached at least 1,200°C or greater.

In sum, the Examiner's allegation that operating Cable's fuel cell at 1,000°C might result in sintering, or fusion, between the electrolyte and electrode is not supported by evidence. The allegation also flies directly in the face of Cable's express teaching, which is to avoid any fusion or bonding of the respective components. Applicants have submitted sufficient evidence to show that a person skilled in the art would not expect any appreciable fusion or sintering to occur in Cable's fuel cell, even when operated at 1,000°C. Applicants therefore respectfully submit that the present claims are allowable over Cable in view of Anumakonda, and respectfully request that the Examiner reconsider and withdraw this rejection.

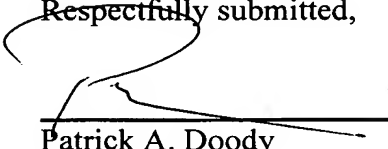
It appears that the Examiner appreciates the differences between the Cable fuel cell and the fuel cell described in the present application. That is, the Examiner appreciates that Cable teaches directly away from a co-fired fuel cell, and that the fuel cell described in applicants' specification is a co-fired fuel cell. The only issue appears to be how to recite this difference in the claims. To the extent the Examiner is not convinced that the present language is sufficient to recite this difference, applicants kindly invite the Examiner to advance prosecution on the merits by providing suggestions as to how the claims may be revised in a manner that adequately reflects the distinction between the prior art and the present invention.

In view of the foregoing, applicants respectfully submit that the present claims are in condition for allowance. An early notice to this effect is earnestly solicited. Should there be

any questions concerning this response, Examiner Yuan is invited to contact the undersigned at the telephone number listed below.

9/23/05  
Date

Respectfully submitted,

  
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